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A Study on Upflow-Anaerobic Sludge Blanket (UASB) Reactor Compare with Conventional Activated Sludge Process

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ABSTRACT

The main aim of the project is to design a UASB reactor instead of an Aeration tank. The discharge flow for the Activated Sludge Process is 8.70 MLD. The UASB reactor had recovered the energy from sewage. The UASB process reduces the volume of the tank and also reduces the size of the plant. The total power requirement of the plant will be 2800 kWh per day during the design flow of 8.70 MLD. Due to usage of UASB reactor, the total power requirement leads to reduce by the Gas turbine. In Indian municipalities, this UASB reactor adopted only a few numbers due to the limitation of the process. This research work suggests the process for the upcoming proposed sewage treatment plant.

Keywords: Activated sludge process; Disposal plant; Effluent; Sewage; UASB reactors.

1. INTRODUCTION

The sewage Treatment Plant is a facility Built to receive the waste from domestic, Industrial and Commercial source and also to Eliminate material that damage water quality and compromise public health and safety when discharged to water receiving systems. Sewage is a system of industrial and domestic wastes. It's More than 99% water, but the rest contains a number of ions, suspended solids, and harmful Bacteria that have to be eliminated before the water is released into the sea. Sewage is generated by the Residential, commercial and institutional, and industrial establishment. It has household waste liquid from toilets, showers, baths, kitchens, sinks, etc that is disposed of through sewers. In most locations, sewage also includes liquid waste from industry and commerce. The draining and separation of household waste to greywater and Blackwater are becoming more common in the developed world, together with greywater being allowed for use for watering plants or recycled for flushing toilets. Sewage may include storm water runoff, Sewerage systems capable of handling storm water are called a combined system. Combined sewer systems are usually avoided now because precipitation causes widely varying flows decreasing sewage treatment plant efficiency. Combined sewers require much large and more expensive treatment facilities compared to sanitary sewers. Heavy storm runoff may overwhelm the sewage treatment system, resulting in a spill or overflow. Sanitary sewers are usually much smaller compared to combined sewers, and they aren't designed to transport stormwater. Backups of raw sewage may happen if excess Infiltration /Inflow is allowed into a sanitary sewer system. Modern sewer developments tend to be provided with separate storm drain for rain. As rain travels over roofs and the ground, it might pick up different contaminants, including soil particles and other sediments, heavy metals, organic compounds, animal waste, and oil and grease.

2. LITERATURE STUDY

M. K. Daud et al. (2018) studied the objective to perform a literature review on the treatment of domestic sewage using the UASB reactor as the core component and to identify future areas of research. The merits of anaerobic and aerobic bioreactors are highlighted, and other sewage treatment technologies are compared with UASB on the basis of performance, resource recovery potential, and cost. HinaRizv et al. (2015) study on the upflow anaerobic sludge blanket reactors seeded with cow dung manure and activated sludge of a dairy wastewater treatment plant were used to treat raw domestic wastewater of medium strength. The rate of removal of these parameters, however, gradually declined with increasing hydraulic retention time. The UASB technology provides a low-cost system for the direct treatment of municipal wastewater and can be applied in small communities. Kanhaiya Kumar Singh et al. (2018) studied the upflow anaerobic sludge blanket reactor seeded with endemic consortia created from municipal wastewater isolates was utilized to treat raw domestic wastewater of medium strength. The UASB innovation gives a minimal effort framework to the immediate treatment of municipal wastewater and can be connected in a small fraternity.

3. CHARACTERISTICS OF SEWAGE

The Quality of sewage can be assessed and examined by studying its physical, Chemical, and biological characteristics according to agreement the expected Raw Sewage Quality along with the agreed Treated Sewage.

Characteristics shall be as follows:

S. No	Parameter	Strong	Medium	Weak
1	Total solids	1200	700	350
2	Dissolved	850	500	250
3	Suspended solids	350	200	100
4	Nitrogen	85	40	20
5	Phosphorous	20	10	6
6	Chloride	100	50	30
7	Alkalinity	200	100	50
8	Grease	150	100	50
9	BOD	300	200	100

3.1 Physical Characteristics of Sewage

Physical examination of sewage is carried out so as to determine its physical characteristics. Including Test for determining,

(a) Turbidity,
(b) Color
(c) Odor
(d) Temperature

3.2 Chemical Characteristics of Sewage

Test conducted for determining the chemical characteristics of sewage indicates that the stage of sewage decomposition and its own strength and type of treatment required for making it secure to the point of disposal.

This includes a Test for determining.

(a) Total solids, suspended solids, and settleable solids
(b) pH value
(c) Chloride content
(d) Dissolved oxygen
(e) BOD
(f) COD

3.3 Biological Characteristics of Sewage

The biological characteristics of sewage are due to the presence of micro-organisms which include bacteria and other living micro-organisms such as algae, fungi, protozoa, etc.

4. COMPOSITION OF SEWAGE

On average, 280000 cumec of sewage arrives each day, although during winter storms this can swell to 800000 m3, of this, 99.9% is water. The remainder is mostly organic matter (800-1000 gm-3), which constitutes the bulk of the suspended solids (250-400 g m-3). The biological process which breaks down this organic matter requires oxygen, and the amount of oxygen required is calculated as the waste water's "biochemical oxygen demand" (BOD). Sewage coming into the plant (influent) has a BOD of between 200 and 400 g m-3 (i.e. 200 to 400 grams of oxygen are required to oxidize each cubic meter of influent). The remaining organic matter consists of fat and grease that form a scum on the surface of the influent. As well as organic matter, small amounts of inorganic ions are also found: The most significant of these are chloride (100-200 g m-3) and sulfide (0.1 -0.7 g m-3). Sulfide, despite its low concentration, is of greater concern than chloride because it is very foul-smelling even at this level. The influent generally contains no dissolved oxygen, so this must be added at various stages of the process to enable the organics to be broken down.

5. PROCESS OF TREATMENT

5.1 Primary Treatment

Pre-treatment removes materials which is easily collected in the raw wastewater before they damage or clog the pumps and sewage lines of primary treatment clarifiers (garbage, tree limbs, leaves, branches etc.).

5.1.1 Screening

The influent sewage water passes through a bar Screen to remove all large objects such as cans, rags, sticks, plastic packets etc. carried in the sewage stream. This is most commonly performed with an automated mechanically raked bar screen in modern plants serving large populations, while in smaller or less modern plants, a manually cleaned screen might be used. The raking activity of a mechanical bar screen is typically paced according to the accumulation on the bar screens and/or flow rate. The solids are collected and afterwards disposed of in a landfill or incinerated. Bar screens or mesh screens of varying sizes may be used to optimize solids removal. If gross solids are not removed, they become entrained in pipes and moving parts of the treatment plant and can cause substantial damage.

Table 1. ISI Standards for discharge of sewage

S. No.	Characteristics of the Effluent	Limit for sewage effluent discharged as per IS 4764-1973	Limit for Industrial effluents discharge into	
			Inland Surface water as per IS 2490-1974	Public sewers as per IS 3306-1974
Unit		Mg/l	Mg/l	Mg/l
1	BOD5	20	30	500
2	COD	-	250	-
3	pH value		5.5 – 9.0	5.5 – 9.0
4	Total Suspended solids	30	100	600
5	Temperature	-	40C	45C
6	Oil or Grease	-	10	100
7	Phenolic compounds	-	1	5
8	Cyanides	-	0.2	2
9	Sulphides	-	2	-
10	Fluorides	-	2	-
11	Total residual chlorine	-	1	-
12	Insectisides	-	0	-
13	Arsenic	-	0.2	-
14	Cadmium	-	2	-
15	Chromium	-	0.1	2
16	Copper	-	3	3
17	Lead	-	0.1	1
18	Mercury	-	0.01	-
19	Nickel	-	3	2
20	Selenium	-	0.05	-
21	Zinc	-	5	15
22	Chlorides	-	-	600
23	% Sodium	-		60%
24	Ammonical nitrogen	-	50	50

5.1.2 Grit Removal

Pre-treatment might include a sand or grit channel or chamber, where the velocity of the incoming wastewater is corrected to allow the settlement of sand, grit, stones, and broken glass. These particles are removed because they might damage pumps and other equipment. For small sanitary sewer systems, the grit chambers might not be necessary, but grit removal is desirable in larger plants.

5.1.3 Primary Sedimentation

At the primary sedimentation stage, sewage flows through big tanks, commonly called"pre-settling basins"," primary sedimentation tanks," or"primary clarifiers". The tanks are used to settle sludge while grease and oils rise to the surface and are skimmed off. Primary settling tanks are often equipped with mechanically driven scrapers that continually drive the collected sludge towards a hopper at the base of the tank, in which it's pumped into sludge treatment facilities. Grease and oil in the floating substance can sometimes be recovered for saponification. The dimensions of the tank should be designed to affect the Removal of a high percentage of their floatables and sludge. A typical sedimentation tank can remove from 50 to 70% of suspended solids and from 30 to 35 per cent of biochemical oxygen demand (BOD) in the sewage.

5.2 Secondary Treatment

Secondary treatment is designed to substantially degrade the biological material of the sewage, which can be derived from human waste, food waste, soaps, and detergent. The majority of municipal plants treat the settled sewage liquor utilizing aerobic biological processes. Secondary treatment systems are classified as fixed-film or suspended-growth systems.

5.2.1 Secondary Treatment Process

Secondary treatment is designed to substantially degrade the biological content of the sewage, which is derived from human waste, food waste, soaps, and detergent. The bacteria and protozoa consume biodegradable soluble organic contaminants (e.g. sugars, fats, organic short-chain Nano-Carbon molecules, etc.) are less soluble

fractions into secondary treatment Methods are Categorized as

- Suspended-growth process (Aerobic & Anaerobic)
- Attached growth process (Aerobic & Anaerobic)
- Both suspended and attached growth process (Aerobic & Anaerobic)

Table 2. Raw Sewage Quality

S. No.	Parameter	Values	Unit of measurement
1	BOD	204 to 212	Mg/l
2	COD	177 to 178	Mg/l
3	Total suspended solids	160	Mg/l
4	Total kjeldahl Nitrogen	95-108	Mg/l
5	Ammonia Nitrogen	86-99	Mg/l
6	Total Phosphorous	9-11	Mg/l
7	Sulphate	72-94	Mg/l
8	Fecal coliform	TNTC	MPN/100ML
9	Total coliform	7000 to 10000	MPN/100ML
10	Chlorides	280-320	Mg/l
11	Ph	6 to 7.5	Mg/l
12	Oil and grease	42	Mg/l
13	Total dissolved solids	1430-1510	Mg/l

Table 3. Treated Effluent Quality

S. No.	Parameter	Values	Unit of measurement
1	BOD	20 or less	Mg/l
2	Total suspended solids	30 or less	Mg/l
3	COD	250 or less	Mg/l
4	Ammonia Nitrogen	Less than or equal to 50mg/l	Mg/l
5	Total phosphorous	5 or less	Mg/l
6	Total coliform	7000 to 10000	Mg/l
7	Ph	5-5.9	Mg/l
8	Oil and Grease	Less than or equal to 5mg/l	Mg/l

5.2.2 Suspended-growth process

Convert soluble and insoluble organic and inorganic compounds flocculent settable microbial suspension to remove the biomass by gravity. Suspended-growth systems include activated sludge, where the biomass is combined with the sewage and may be operated in a smaller area than trickling filters which treat the identical amount of water. Roughing filters are intended to treat particularly strong or variable organic loads, typically industrial, to allow them to then be treated by conventional secondary treatment processes.

Characteristics include filters full of media to that wastewater is applied. They are designed to allow high hydraulic loading and a high degree of attraction. On larger installations, the Air is forced through the media using blowers. The resultant wastewater is generally within the normal range for the conventional treatment process.

A filter removes a small percentage of their suspended organic matter, although the vast majority of the organic matter undergoes a change of character, just due to the biological oxidation and nitrification occurring from the filter. With this particular aerobic oxidation and nitrification, the organic solids have been converted to coagulated suspended mass that is heavier and bulkier and will settle to the bottom of the tank. The effluent of this filter is therefore passed through a sedimentation tank, also called a secondary clarifier, secondary settling tank or humus tank.

Eg: 1. Aeration tank Oxidation pond, Oxidation ditch,(Aerobic process)
2. Septic tank, UASB (Anaerobic process)

5.2.3 Attached growth process

Conversion of colloidal, dissolved, and residential attached organic matter into stable inorganics.

E.g.: Trickling filter, Rotating Biological contactor.

5.2.4 Activated Sludge Process

Generally, activated sludge plants encompass many different mechanisms and processes using dissolved oxygen to promote the growth of biological which substantially eliminates organic material. More than 80% of the existing wastewater treatment plants the activated sludge process in which the suspended bacteria oxidize the carbonaceous and nitrogen compounds so that effluents in accordance with the imposed standards are obtained. The biological process was improved during the last few years. One of these new processes is obtained by the addition of specially designed mobile elements into the aeration tank that provides the carriers for biological growth. This is best applied at extended aeration plants or conventional activated sludge facilities. For this process, an oxygen-deficient zone (typically 15% of the aeration tank volume) is created to allow the activated sludge bacteria to use the nitrate to oxidize

waste BOD. From this process, nitrogen gas is created as denitrification occurs.

Advantages

1. Allows good nitrification since COD is uniformly low.
2. Able to handle peak loads and dilute toxic substances.
3. Used in smaller systems, like package plants.

Disadvantages

1. Larger volume, high aeration costs.
2. Not much operational flexibility.
3. It is associated with biomass instabilities like sludge bulking.

6. PROCESS DONE IN KOYEMBEDU WASTE DISPOSAL PLANT AND FAILURE

6.1 The process is done in the Koyembedu waste disposal plant.

1. The vegetable waste is collected and taken into the treatment plant.

2. The waste is taken into the hopper, and vegetables are grinded and cut in the hopper and the waste are took into the flocculation chamber.

3. The waste is treated, and the chemical and biogas such as methane, alkane, and biogas are collected and used for electricity purposes.

4. Their main aim is to supply electricity for large scale, which is collected from vegetable waste but it was not possible due to the inefficiency of the machines which are provided, so the current supply is done only to that treatment plant.

5. The odors from the flocculation chamber are removed by passing those waste to coconut shell fibers which are shown in direct sunlight.

6.2 Failure of Koyembedu waste disposal plant

1. The plant faced glitches with the engine failing, and for few years, the Biogas was not put to any use.
2. From 2008, until 2011 the plant functioned only for 4 months because of the machine not working and due to the poor quality of waste fed into it.
3. They were unable to run the plant owing to a lack of space for source segregation and composting.

7. UASB PROCESS

Anaerobic treatment is now becoming a popular treatment method for industrial wastewater because of its effectiveness in treating high-strength wastewater and because of its economic advantages. In recent years, the number of anaerobic reactors in the world is increasing rapidly, and about 72% consist of reactors based on the UASB and EGSB technologies. In UASB process, it maintains a high concentration of biomass through the formation of highly settle able microbial sludge aggregates. The wastewater flows upwards through a layer of very active Sludge to cause anaerobic digestion of organics of their wastewater. At the top of the reactor, a three-phase separation between gas-solid-liquid takes place. Any biomass leaving the reaction zone is directly recirculated in the settling zone. The process is suitable for both soluble wastewaters as well as wastewaters containing particulate matter. From the UASB process, the entire waste is passed via the anaerobic reactor in an up flow mode, using a hydraulic retention time (HRT) of only about 8-10 hours at average flow. No prior sedimentation is required. The anaerobic unit does not have to be full of stones or any other media; the up flowing sewer itself creates thousands of small “granules" or particles of sludge that are held in suspension and provide a large surface area on which organic matter could attach and experience biodegradation. A high solid retention time (SRT) of 30-50 or more days occurs within the unit. No mixers or aerators are required. The gas produced can be accumulated and utilized if desired. The anaerobic system functions satisfactorily when temperatures inside the reactor are above18-20ºC. Surplus sludge is removed from time to time via a separate pipe and sent to some very simple sand bed for drying. The methane generated can be used as a gas for domestic or industrial use. It may also be used for the generation of electricity for running the plant after appropriate dehydration and cleaning. This process can be reactivated even after the plant remains shut down for days or months or after power breakdowns and interruptions in wastewater supply.

The sludge granules have many advantages over conventional sludge flocs:

- -Dense compact bio-film
- -High settle-ability (30-80 m/h)
- -High mechanical strength
- -Balanced microbial community
- -Syntrophic partners closely associated
- -High methanogenic activity (0.5 to 2.0g COD/g VSS.d)

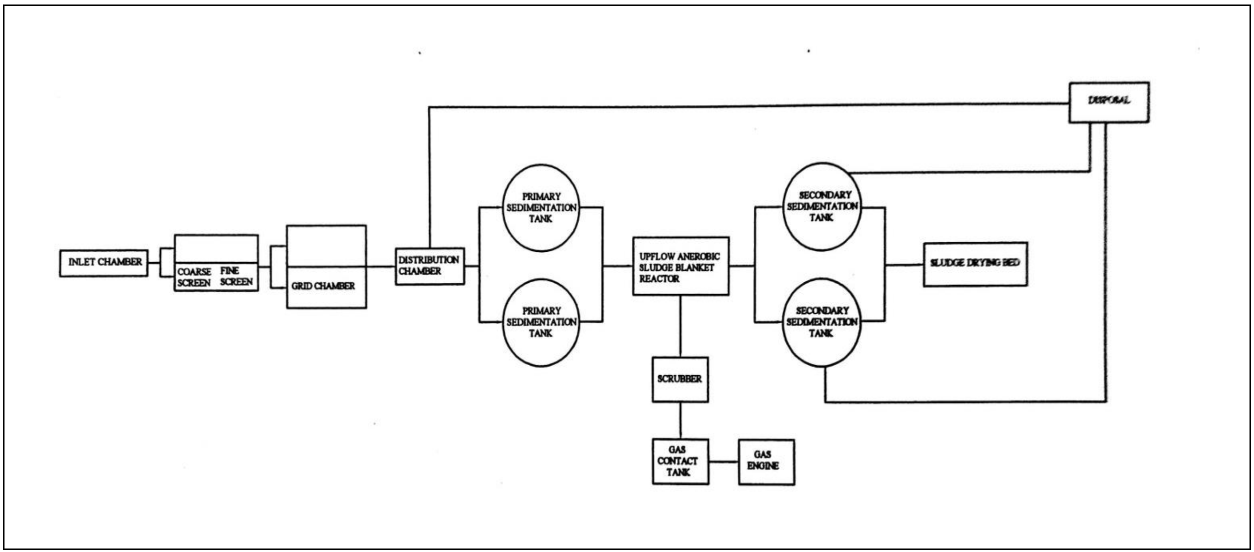

Fig. 1: Sewage Treatment Process

8. LIMITATIONS

1. The system helps to lower only two parameters of wastewater, such as BOD and suspended solids.

2. Like all other anaerobic high rate systems, the UASB reactor also requires a large quantity of organic matter as compared to anaerobic reactors.

3. The acids produced during the breakdown of organic matter in a UASB reactor may cause corrosion of the reactor.

4. Pre-treatment of wastewaters with screening and grit removal is usually found necessary for direct anaerobic treatment.

5. The system responds well in high-temperature climate areas because the activity of methanogenic bacteria is strongly influenced by temperature. However, high micro-organism in high rate anaerobic reactors like UASB, compensates for the decreased activity of anaerobic organisms at lower temperatures.

6. The installation of UASB plant should be made a mandatory requirement of developing every new colony or township, having a population of more than 5000.
7. It is evident that a long solids residence time (SRT) is necessary for the treatment of sewage by anaerobic processes because of the low specific growth rates associated with anaerobic bacteria.

8. Fixed-film microbial growth provides intimate contact between the various anaerobic bacteria, thereby providing rates of reaction and degrees of stability that cannot be obtained in suspended growth systems.

9. In general, the UASB reactor did not use primary treatment, while anaerobic expanded or fluidized bed reactors did. The reason for this lies in the mechanisms of particle entrapment and hydrolysis in the two systems.

10. If that is the case, then anaerobic sewage treatment may be economically feasible only in warmer.

9. CONCLUSION

1. Anaerobic treatment often is environmental friendly and very cost-effective in reducing discharge combined with the production of reusable energy in the form of biogas.
2. Anaerobic treatment of domestic wastewater can also be very interesting and cost-effective in countries where the priority in discharge control is in the removal of organic pollutants.
3. The Space requirement of the system is quite comparable to that of an Activated sludge system.
4. The System requires lesser and simpler electromagnetic parts as compared to the ones required in the Activated Sludge plant leading to Operation and maintenance costs.
5. Electricity consumption in this system, like all anaerobic system is quite low, and the system is quite capable of withstanding long power failures.
6. Sludge Production is low, and produced sludge has quick dewatering characteristics.

7. It enables quicker sludge digestion as compared to conventional digestors.
8. Biogas is produced in this system as a by-product, which can be used to produce electricity to run the system.

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